Doping characteristics for WS$_x$Se$_y$ Monolayer

The transition metal dichalcogenides (TMDs) have attracted much attention because of their unique characteristics and potential application in the low-power and optoelectronic devices. Recent reports have successfully demonstrated the growth of 2-dimensional MoS$_x$Se$_y$, WS$_x$Se$_y$, Mo$_x$W$_y$S$_2$ and Mo$_x$W$_y$Se$_2$ alloys, where these materials exhibit tunable band gap energies. However, few literatures focus on the doping behaviors in those 2D monolayer alloys. In the study, we report that WS$_x$Se$_y$ monolayer alloys were synthesized using tungsten oxides, selenium and sulfur powders as the sources in the CVD process, where different heating temperatures of selenium and sulfur powders are applied respectively for controlling the ratio of S to Se. The optical band gap of the as-grown WS$_x$Se$_y$ monolayer alloys from 2.0 eV to 1.64 eV is precisely tunable via the different chalcogenide heating temperature. With the increase of selenium in WS$_x$Se$_y$ monolayers, apparent electronic state transform from p-type to n-type were recorded through energy band diagrams, beneficial for the future optical design.

References


Figures

**Figure 1:** Raman spectra of pristine WS$_2$, WSe$_2$ and as-grown WS$_x$Se$_y$ monolayers. The WS$_2$-related Raman characteristic peaks, $A_{1g}$ and $E_{2g}$, of the as-grown WS$_x$Se$_y$ monolayers were a blue shift because of the change of carrier concentration toward n-doping. Meanwhile, redshift for WSe$_2$-related Raman peaks may result from the change of carrier concentration toward p-doping.